DOCUMENT RESUME

ED 050 554 EM 008 914

AUTHOR	Merrill, Paul F.
TITLE	Task Analysis: An Information Processing Approach.
INSTITUTION	Florida State Univ., Tallahassee. Computer-Assisted Instruction Center.
SPONS AGENCY	Office of Naval Research, Washington, D.C. Personnel and Training Research Programs Office.
PUB DATE	15 Apr 71
NOTE	30p.; CAI Center Tech Memo Number 27
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	Association (Psychological), Behavioral Objectives, Behavior Chaining, *Information Processing, Learning Processes, *Learning Theories, *Models, *Task Analysis, Task Performance, Thought Processes
IDENTIFIERS	*Gagne (R M)

ABSTRACT

Several concepts and techniques used to design computer simulation of human performance were employed in developing an information processing approach to task analysis. This new approach is compared and contrasted with Gagne's hierarchical task analysis model. Two conceptual levels of a behavioral objective are identified. One level, referred to as the "task level," is concerned with the determination of the subskills that are required to learn and perform the terminal objective of a task. The second level, the "rule level," is concerned with the discovery of order relationships between subskills. Neither hierarchical nor information processing analysis would be sufficient for all types of tasks. A hierarchical analysis would be appropriate where lower ordered skills generate positive transfer to higher level skills, while an information processing analysis would be utilized where the output of one task subskill or operation is required as input for a succeeding operation (behavior chaining). (Author/JY)

ED050554

CAI CENTER

TECH MEMO

TASK ANALYSIS - AN INFORMATION PROCESSING APPROACH

Paul F. Merrill

Tech Memo No. 27
April 15, 1971

Project NR 154-280
Sponsored by
Personnel & Training Research Programs
Psychological Sciences Division
Office of Naval Research
Arlington, Virginia
Contract No. N00014-68-A-0494

FLORIDA STATE UNIVERSITY

M008 914

Tech Memo Series

The FSU-CAI Center Tech Memo Series is intended to provide communication to other colleagues and interested professionals who are actively utilizing computers in their research. The rationale for the Tech Memo Series is three-fold. First, pilot studies that show great promise and will eventuate in research reports can be given a quick distribution. Secondly, speeches given at professional meetings can be distributed for broad review and reaction. Third, the Tech Memo Series provides for distribution of pre-publication copies of research and implementation studies that after proper technical review will ultimately be found in professional journals.

In terms of substance, these reports will be concise, descriptive, and exploratory in nature. While cast within a CAI research model, a number of the reports will deal with technical implementation topics related to computers and their language or operating systems. Thus, we here at FSU trust this Tech Memo Series will serve a useful service and communication for other workers in the area of computers and education. Any comments to the authors can be forwarded via the Florida State University CAI Center.

Duncan N. Hansen
Director
CAI Center

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Florida State University Computer-Assisted Instruction Center Tallahassee, Florida	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Task Analysis - An Information Processing Approach

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical Memo No. 27, April 15, 1970

5. AUTHOR(S) (First name, middle initial, last name)

Paul F. Merrill

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
April 15, 1971	17	16

8a. CONTRACT OR GRANT NO. N00014-68-A-0494 b. PROJECT NO. NR 154-280 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Personnel & Training Research Program Office of Naval Research Arlington, Virginia

13. ABSTRACT

Several concepts and techniques used to design computer simulation of human performance were used in developing an information processing approach to task analysis. This new approach was compared and contrasted with Gagne's hierarchical task analysis model. Neither hierarchical nor information processing analysis would be sufficient for all types of tasks. A hierarchical analysis would be appropriate where lower ordered skills generate positive transfer to higher level skills, while an information processing analysis would be utilized where the output of one task subskill or operation is required as input for a succeeding operation.

DD FORM 1473 (PAGE 1)
1 NOV 65
S/N 0101-807-6811

Security Classification
A-31408

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT

DD FORM 1 NOV 65 1473 (BACK)
S/N 0101-807-6821

Security Classification
A-31409

TASK ANALYSIS - AN INFORMATION PROCESSING APPROACH

Paul F. Merrill

Tech Memo No. 27
April 15, 1971

Project NR 154-280
Sponsored by
Personnel & Training Research Programs
Psychological Sciences Division
Office of Naval Research
Arlington, Virginia
Contract No. N00014-68-A-0494

TASK ANALYSIS - AN INFORMATION PROCESSING APPROACH

ABSTRACT

Several concepts and techniques used to design computer simulation of human performance were used in developing an information processing approach to task analysis. This new approach was compared and contrasted with Gagné's hierarchical task analysis model. Neither hierarchical nor information processing analysis would be sufficient for all types of tasks. A hierarchical analysis would be appropriate where lower ordered skills generate positive transfer to higher level skills, while an information processing analysis would be utilized where the output of one task subskill or operation is required as input for a succeeding operation.

TASK ANALYSIS - AN INFORMATION PROCESSING APPROACH[1]

Paul F. Merrill

Florida State University

The purpose of this paper is to propose and describe an information processing approach to the problem of task analysis. In addition, this new approach will be compared and contrasted with Gagné's hierarchical task analysis model (Gagné, 1962, 1968, 1970). A learning task or behavioral objective may be analyzed at two different conceptual levels. An analysis at the first level, which shall be referred to in this paper as the ''task level,'' is concerned with the determination of the subskills that are required to learn and perform the terminal objective of a task. Analysis at the ''task level'' is also concerned with the discovery of ordered relationships between the subskills. On the other hand, an analysis at the second, or ''rule level'' entails the determination of the most effective instructional paradigm for teaching a particular subskill, rule, or operation. Briggs (1968) has made a similar distinction between ''what is taught'' and ''how it is taught.''

Although there are strong implications for the use of information processing techniques in the analysis of tasks at the ''rule level,'' the major thrust of this paper will be to describe the manner in which an information processing approach may be used to analyze a learning task or terminal behavior at the ''task level.'' Evans, Homme, and Glaser (1962) have suggested that task subskills may be related according to: 1) complexity (from the simple to the complex), 2) chronology (time sequencing often

[1]The collaboration of William P. Olivier and C. Victor Bunderson with the author in the early formulation and devlopment of the ideas presented in this paper is gratefully acknowledged.

used in history courses), 3) spatiality (as in a geography program), or 4) interdependencies (as in a mathematics program). The task analysis models which will be described and contrasted in this paper are concerned with the analysis of tasks with subskills related according to Evans, Homme, and Glaser's fourth category of interdependence (Evans et al., 1962).

The most widely accepted model of task analysis for determining the interdependencies between subskills has been proposed by Gagné, (1962). He proposed that in analyzing a terminal objective it is possible to define a hierarchy of subskills such that lower ordered skills or behaviors would generate positive transfer to skills at a higher level. Such an analysis may be performed by starting with the terminal behavior and identifying subordinate skills by asking the question: ''What would an individual already have to know how to do in order to learn the new capability simply by being given verbal instructions?'' This question is asked recursively of each subbehavior identified until the assumed student entry behaviors are determined. In the strictest sense, the question quoted above implies that an individual must already know how to do subordinate behaviors before he can learn a higher or superordinate level behavior. In an empirical sense, the question implies that subordinate skills will facilitate or transfer positively to the learning of superordinate skills.

Although Gagné's hierarchical task analysis has received considerable empirical support in a number of studies using mathematical materials (Gagné, 1962; Gagné and Paradise, 1961; Gagné, Major, Garstens, and

Paradise, 1962), some instructional designers have attempted to used Gagné's procedure to analyze tasks in which subskills are not hierarchically related. The inappropriate use of this procedure has led to the erroneous conclusion that certain subskills of a given task must be learned before other subskills can be taught. The subskills for many tasks are not interdependently related, and the subskills for other tasks have information processing interdependent relationships rather than hierarchical relationships.

Information Processing Approach

If the terminal behavioral of a task requires an individual to perform a set of subskills which have an information processing relationship, then the task may be thought of as an information processing task or procedure. An information processing procedure may be defined as one which requires one or more inputs from a given domain and produces one or more outputs having a specified relationship to the inputs (Knuth, 1968). This definition implies that the subskills or operations of a task have an information processing relationship if, and only if, the result or outputs of one operation are required as part of the inputs for a succeeding operation. This ''output-input'' relationship of an information processing procedure is demonstrated in Figure 1. The output of the summing operation becomes the input for the succeeding division operation. Obviously, the sequence for performing the operations of such a task becomes very crucial. It would be impossible to perform correctly certain operations of the procedure until the results or outputs of previous operations had been obtained.

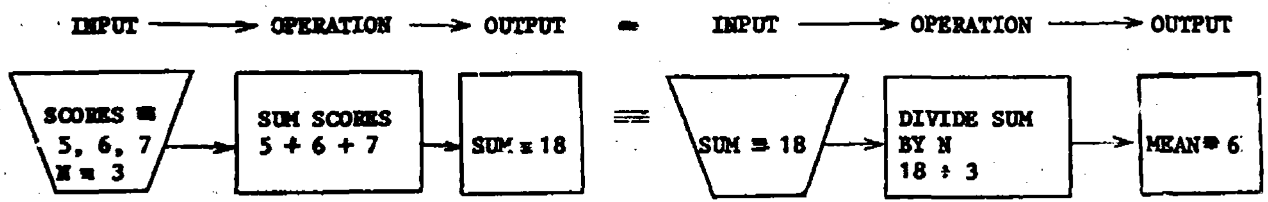

Figure 1.--Output - Input Relationship of an Information Processing Procedure

An information processing task may be thought of as either an algorithmic procedure or a heuristic procedure. An algorithmic procedure consists of a set of operations which are guaranteed to produce the terminal behavior, while a heuristic procedure is made up of ''rules of thumb'' which generally will lead to a solution but do not guarantee the attainment of the terminal behavior.

The subskills required to perform an information processing task may be determined by analyzing how a man goes about performing the task. If the task requires physical activity, an observation of the man actually performing the task should be conducted. If the task entails cognitive operations, it may be necessary to use a technique such as that described by Feldman (1963) where a man is asked to ''think aloud'' while performing the task. Detailed notes may be made concerning the information or objects being operated upon, the specific operations being performed, the results of each operation, and all decision points encountered. The purpose of this analysis is not to determine how a naive or untrained person would approach the given task, but to determine the most efficient and effective procedure for performing the task. Therefore, the man who is observed and asked to ''think aloud'' should be an expert, or in Gilbert's terms, a ''master'' at the task (Gilbert, 1962).

The information obtained during the observation may be used to outline the information processing procedure. The steps of the procedure should be specified in a precise and unambiguous manner, and each step should be stated in terms of a process or operation to be performed. A flow-chart of the procedure should be drawn which shows the sequence for performing the operations, the decision point branches, and any required

iterative loops. The validity of the flowchart and corresponding procedure may be determined by stepping through each operation of the flowchart by hand, using several different initial inputs. Care should be taken to verify that the necessary inputs are available for each successive operation. These inputs may be available either from initial inputs or from the outputs from previous operations. Decision point branches should be checked to make sure they provide for all possible contingencies.

Figure 2 is a flowchart of an information processing procedure for reconciling a bank statement. This particular task is usually taught in a high school general business course and requires the performance of both physical and cognitive operations. An examination of the flowchart will reveal that the output or results from earlier operations are used as inputs for succeeding operations. However, these steps are not hierarchically related, since a person could learn how to do later steps without knowing how to perform earlier steps. The flowchart also depicts the fact that certain successive operations in the procedure may not have information processing interdependencies. For example, the operations labeled 4, 5, and 6 are not interdependent and may be performed in any order. However, the independent output of each of these operations is required as part of the input for the performance of operation number 7.

The size of the steps or complexity of the operations specified in the flowchart may be somewhat arbitrary. The appropriate degree of complexity for each operation is dependent upon the processing capabilities of the target population which must perform the operation. A determination of the optimal complexity for the operations which will be executed by

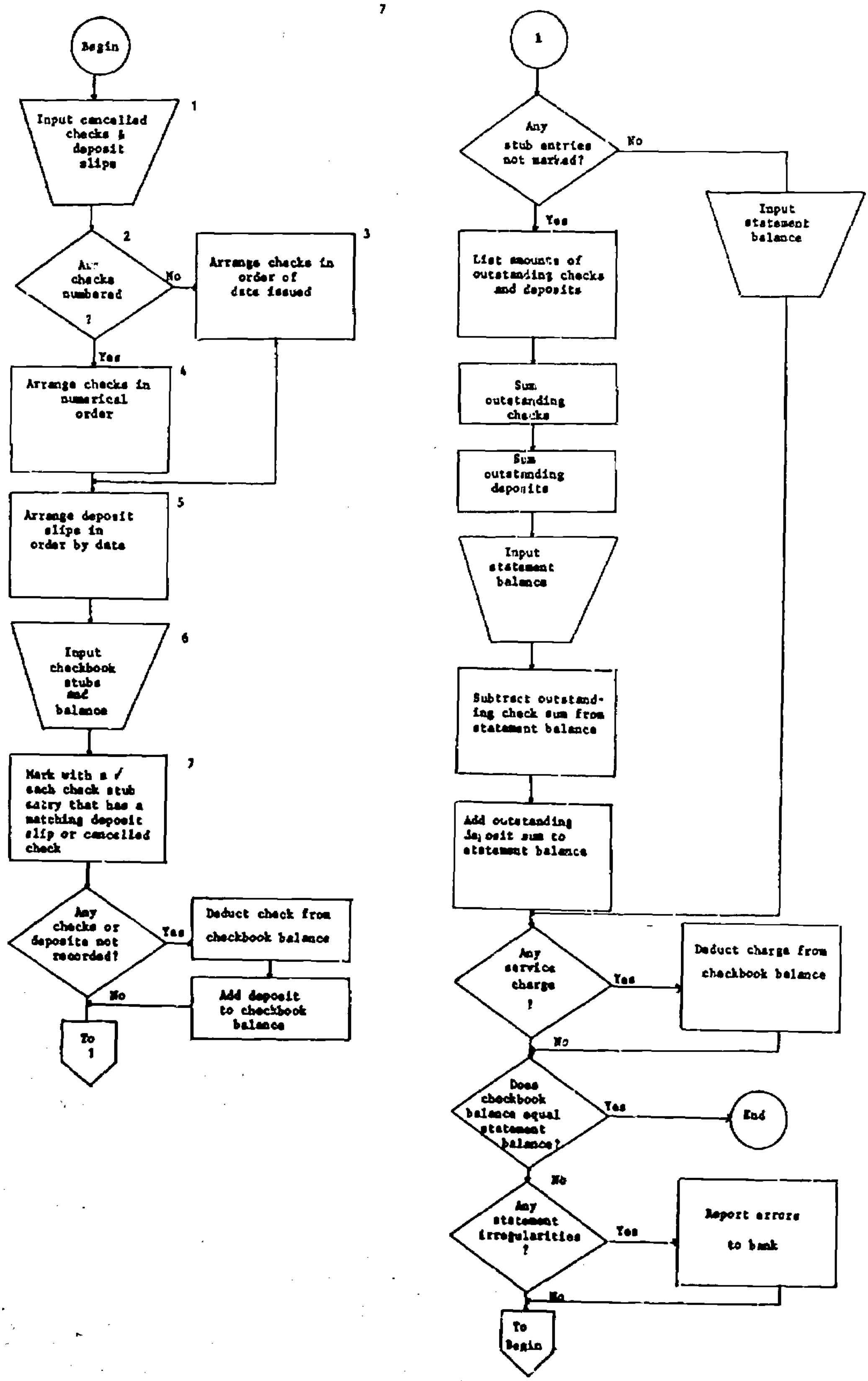

Figure 2.--Information Processing Flowchart for Reconciling a Bank Statement

a given population of subjects is an empirical problem. In the context of the mathetics approach, Gilbert (1962) has suggested that the individual operants should be combined into the largest behavioral unit that a student can reasonably perform. An overestimation of the ''operant span'' will be discovered in an empirical tryout and can be easily rectified. However, an underestimation would not lead to any errors and therefore would be very difficult to discover. If an empirical tryout reveals that students are unable to perform a certain operation of the procedure, that operation may be further analyzed into its suboperations. For example, if subjects were unable to perform the fourth operation of ''arranging checks in numerical order,'' a subprocedure for performing a numerical sort could be specified.

For many complex tasks, there may be more than one information processing procedure for performing the terminal behavior. If this is the case, a comparative evaluation of the procedures should be made. The length of time and number of operations required to perform the different procedures given several initial inputs should be compared. The procedures could also be evaluated in terms of Bruner's (1966) concepts of economy and power. He suggests that economy is a function of the sequence of presentation where one procedure may require storage of information, while another may require a more pay-as-you-go type of information processing. In terms of power, one procedure may more enable a student to generate new hypotheses and combinations than some other procedure.

A Comparison of Task Analysis Techniques

When any new approach is presented for attacking an old problem, the first question posed by critics is: ''What is the difference between this new approach and already existing techniques?'' Obviously, many of the ideas embodied in a new approach will be very similar to ideas used in other approaches to the same problem. The hierarchical task analysis procedure (Gagné, 1962) and the information processing analysis both reveal a structure of skills or operations having an ordered relationship to each other. However, the nature of this ordered relationship is considerably different. Two skills or operations have a hierarchical relationship if the learning of one skill is prerequisite to the learning of the other skill. In contrast, two skills or operations have an information processing relationship if the outputs of one operation are required as part of the inputs for another operation. Thus, for hierarchically related skills the learning sequence is important, while for information processing related skills the performance sequence is critical. The use of a hierarchical task analysis procedure to analyze a task which has information processing relationships can lead to erroneous conclusions concerning the relationships between certain operations. For example, one student attempted to conduct a hierarchical analysis of the objective ''the student will be able to apply the rule: Work = Force x Distance'' and concluded that the capabilities of measuring distance and force were hierarchically related to the application of the rule. However, such a conclusion was erroneous since a student can learn how to apply the rule without first learning how to measure distance and force. On the

other hand, the measurement of distance and force do have an information processing relationship to the application of the rule since the rule cannot be correctly applied unless the inputs of distance and force are available. In another case, a hierarchical analysis of the terminal objective ''Each student will produce and document a programmed course of instruction'' was conducted. From the resulting block diagram, one would be led to conclude that before a student could learn how to conduct a summative evaluation he would have to be able to write a programmed text. It is obvious that the summative evaluation of a text cannot be performed until the text is written (an information processing relationship), but the person performing the summative evaluation does not need to know how to write the text being evaluated.

The point of this differentiation between ordered relationships seems to be that neither hierarchical nor information processing analysis is sufficient or applicable for all types of tasks. If in performing a given task, the outputs of one operation are required as inputs for a succeeding operation, then an information processing analysis would be appropriate. On the other hand, a hierarchical analysis would be conducted when one subskill of a task must be learned before another subskill can be learned. If the subskills of a task are not interdependent, then neither the hierarchical nor the information processing analysis would be appropriate. However, one of the major purposes for conducting a task analysis is to discover the nature of the subskill relationships. Therefore, an instructional designer should analyze a given task using both techniques in order to discover if either type of relationship exists. Some tasks,

especially mathematical tasks, may have both types of relationship. For example, the task of ''simplifying an equation by adding and subtracting terms to both sides,'' described and analyzed by Gagné and Paradise (1961), not only has a hierarchical structure, but is performed by using an algorithmic information processing procedure. By conducting both types of analysis, an instructional designer will obtain a broader understanding of the actual nature of a given task and its subskill relationships.

Information Processing Procedures and Chains

On the surface it may appear that an information processing procedure is just a fancy title given to a behavioral chain. However, the following discussion will attempt to show that it is profitable to distinguish between the two terms.

A common referent for the concept ''chain'' is a series of interlocking links. However, the word ''chain'' has been extended by analogy to refer to the psychological phenomena of a series of ''linked'' behaviors. Mechner (1967, p.87) defines a behavioral chain as ''...a sequence of responses where each response creates the stimulus for the next response.'' A slightly different definition is given by Gilbert (1962, p.10): ''A behavior chain is a sequence of stimuli, responses, and reinforcers in which the reinforcer for one response is also the stimulus for the next response.'' These definitions were originally used to describe the phenomenon of an animal going through a series of complex behaviors before being reinforced with a food pellet. Gilbert (1962) cites the example of a rat pulling a lamp cord to turn on a light, then pressing a lever to sound a buzzer, and then going to the food pan to receive a pellet. However, humans

also execute many series of linked behaviors. Reciting the alphabet, tying a shoe lace, writing a name, and reciting a poem are only a few examples of behavioral chains used by humans.

Mechner (1965, 1967) also classifies the following behaviors as chains: (1) conducting a qualitative chemical analysis, (2) troubleshooting, and (3) solving a mathematical problem. However, these examples are considerably more complex than the examples cited above. These complex behaviors listed by Mechner have several additional characteristics not covered in the definition of a chain. Because of these additional characteristics, these behaviors would more properly be classified as information processing procedures. Although a behavioral chain and an information processing procedure both involve a series of behaviors or operations, the nature of the link or relationship between consecutive operations is considerably different. The link of a chain is formed by the response to one stimulus serving as a stimulus for the next response. However, the links in an information processing procedure have the additional characteristic of the output of one operation or response serving as an input to the next operation. In the former case, a discriminative stimulus serves as the occasion for the next response, while in the latter case the output of a previous operation not only serves as a cue for the next operation, but it is also used as input data for the succeeding operation.

A further distinction between chains and information processing procedures can be derived from the basic difference described above. Since the response to one stimulus merely serves as the occasion or stimulus for the next response in a chain, it logically follows that the final response to any given chain will always be invariant. In contrast, the

final output of an information processing procedure is dependent upon the given initial inputs. From this distinction it also follows that information processing procedures may have decision points with corresponding branches and/or loops, while chains will always be linear.

There is another type of procedure which is a hybrid of the information processing procedure and the chain. This hybrid procedure is analogous to a computer subroutine that does not have any input parameters. Without any variable inputs, such a procedure will be linear and will always produce the same output. However, the outputs of early operations may serve as inputs to succeeding operations. In contrast, an information processing procedure is analogous to a computer subroutine with variable input parameters.

Learning Sequence

One of the purposes for conducting an analysis at the ''task level'' is to determine the most effective sequence for learning the subskills or operations required to perform the terminal task. It cannot be assumed without supporting empirical evidence or logical argument that the most appropriate sequence for performing a series of operations is also the most appropriate sequence for learning the operations. However, Stolurow (1962) hypothesized that sequential arrangements may be found to make a difference in students' cognitive structure and thereby affect their behavior. Since an information processing task must be performed in a certain order, the instructional sequence used to teach the task should facilitate the students' efforts to organize and structure an efficient strategy for performing the task. Therefore, an effective instructional

sequence would be one which clearly showed the output-input relationships between successive operations. These relationships would be clarified by using a sequence which corresponded to the order for performing the operations. This assertion was put to an empirical test in a study by Olivier (1971). In this study the relationship between posttest performance and the degree of conformity to an information processing sequence was investigated. An imaginary science was used as the learning task. A sequence-conformity index was developed to quantify various degrees of nonconformity to the information processing sequence for performing the task. The index had values ranging from zero to unity. A value of 1.00 was assigned for learning the operations in the proposed sequence, and a value of 0.00 was assigned for learning the operations in a completely reversed order. Intermediate values were assigned for various degrees of nonconformity to the information processing sequence.

The results showed that posttest performance decreased as the degree of conformity to the information processing sequence decreased from 1.00 to .25. However, posttest performance increased again when the sequence was completely reversed (index value of 0.00). Ss with an index of 1.00 performed significantly higher on the posttest ($t(47) = 2.72$, $p < .01$) than Ss with an index of .25. These results only partially support the assertion that the operations of an information processing task should be taught in the same sequence in which they should be performed. Additional studies should be conducted to determine if Olivier's findings would be replicated using different information processing tasks.

The effectiveness of the completely reversed sequence leads to the hypothesis that the retrogression sequence suggested by Gilbert (1962) to establish chains might also be effective for teaching an information processing procedure. Other methods for showing the output-input relationships between successive operations of an information processing task, such as Ausubel's ''advanced organizers'' (Ausubel, 1968) and Gilbert's ''Domain Theory'' (Gilbert, 1962) should also be investigated.

Summary

Several concepts and techniques used to design computer simulations of human performance were used in developing an information processing approach to task analysis. This new approach was compared and contrasted with Gagné's hierarchical task analysis model. Neither hierarchical nor information processing analysis would be sufficient for all types of tasks. A hiererchical analysis would be appropriate where lower ordered skills generate positive transfer to higher level skills, while an information processing analysis would be utilized where the output of one task subskill or operation is required as input for a succeeding operation.

REFERENCES

Ausubel, D.P. Educational psychology: A cognitive view. New York: Holt, Rinehart & Winston, 1968.

Briggs, L. J. Sequencing of instruction in relation to hierarchies of competence. Pittsburgh: American Institutes for Research, 1968.

Bruner, J. S. Toward a theory of instruction. Cambridge: Harvard University Press, 1966.

Evans, J. L., Houme, L. E., & Glaser, . The ruleg system for the construction of programmed verbal learning sequences. The Journal of Educational Research, 1962, 55, 513-518.

Feldman, J. Simulation of behavior in the binary choice experiment. In E. A. Fergenbaum & J. Feldman (Eds.), Computers and thought. New York: McGraw Hill, 1963.

Gagné, R. M. The acquisition of knowledge. Psychological Review, 1962, 69, 355-365.

Gagné, R. M. The conditions of learning. (2nd ed.) New York: Holt, Rinehart & Winston, 1970.

Gagné, R. M. Learning hierarchies. Educational Psychologist, 1968, 6, 1-9.

Gagné, R. M., Major, J. R. Garstens, H. L., & Paradise, N. E. Factors in acquiring knowledge of a mathematical task. Psychological Monographs, 1962, 76, No. 526.

Gagné, R. M., & Paradise, N. E. Abilities and learning sets in knowledge acquisition. Psychological Monographs, 1961, 75, No. 518.

Gilbert, T. F., Mathetics: The technology of education. Journal of Mathetics, 1962, 1, 7-73.

Knuth, D. E. The art of computer programming. Vol. 1 Fundamental Algorithms. Reading, Mass.: Addison-Wesley Publishing Co., 1968.

Mechner, F. Science education and behavioral technology. In R. Glaser (Ed.), Teaching machines and programed learning, II: Data and directions. Washington, D. C.: National Education Association, 1965.

Mechner, F. Behavioral analysis and instructional sequencing. In P.C. Lange (Ed.) Programed instruction. Chicago: The National Society for the Study of Education, 1967.

Olivier, W. P. Learner and program-controlled sequences of computer-assisted instruction. Paper presented at the annual meeting of the American Educational Research Association, New York, February, 1971.

Stolurow, L. M. Implications of current research and future trends. The Journal of Educational Research, 1962, 55, 519-527.

MILITARY MAILING LIST

Dr. Ray Berger
Electronic Personnel Research Group
USC
Los Angeles, California 90007

Chief of Naval Research
Code 458
Department of the Navy
Arlington, Va. 22217

Director
ONR Branch Office
219 Dearborn Street
Chicago, Illinois 60604
Att: Dr. Morton Bestin

Office of Naval Research
Area Office
207 West Summer Street
New York, New York 10011

Director
Naval Research Laboratory
Washington, D.C. 20390
Attn: Technical Information Div.

Commanding Officer
Service School Command
U.S. Naval Training Center
San Diego, California 92133

Commanding Officer
Naval Medical Neuropsychiatric
Research Unit
San Diego, California 92152

Dr. James J. Regan
Code 55
Naval Training Device Center
Orlando, Florida 32813

Col. Ray Alvord
FR 19995
Air Force Institute of Technology
SLG
Wright-Patterson Air Force Base,
Ohio 45433

Mr. Norman B. Carr
Educational Advisor
U.S. Army
Southeastern Signal School
Ft. Gordon, Georgia 30905

Director
ONR Branch Office
495 Summer Street
Boston, Massachusetts 02210
Att: Dr. Charles Starsh

Director
ONR Branch Office
1030 East Green Street
Pasadena, California 91101
Att: Dr. Eugene Gloye

Office of Naval Research
Area Office
1076 Mission Street
San Francisco, California 94103

Defense Documentation Center
Cameron Station, Building 5
5010 Duke Street
Alexandria, Virginia 22314

Commanding Officer
Naval Personnel & Training Res. Lab.
San Diego, California 92152

Commanding Officer
Naval Air Technical Training Center
Jacksonville, Florida 32213

Chief, Naval Air Reserve Training
Naval Air Station
Box 1
Glenview, Illinois 60026

Behavioral Sciences Department
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

Technical Library
U.S. Naval Weapons Laboratory
Kahlgren, Virginia 22448

Technical Library
Naval Ship Systems Command
Main Navy Building, RM. 1532
Washington, D.C. 20360

Library, Code 0212
Naval Postgraduate School
Monterey, California 93940

Technical Library
Naval Ordnance Station
Louisville, Kentucky 40214

Commanding Officer
U.S. Naval Schools Command
Mare Island
Vallejo, California 94592

Scientific Advisory Team (Code 71)
Staff, COMASWFORLANT
Norfolk, Virginia 23511

ERIC Clearinghouse
Vocational and Technical Education
Ohio State University
Columbus, Ohio 43212

Office of Civilian Manpower
Management
Department of the Navy
Washington, D.C. 20390
Attn: Code 024

Chief of Naval Material (Mat 031M)
Room 1323, Main Navy Building
Washington, D.C. 20360

Chief
Bureau of Medicine and Surgery
Code 513
Washington, D.C. 20390

Chief, Naval Air Technical Training
Naval Air Station
Memphis, Tennessee 38115

Technical Library
Naval Training Device Center
Orlando, Florida 32813

Mr. Philip Rochlin, Head
Technical Library
Naval Ordnance Station
Indian Head, Maryland 20640

Technical Reference Library
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

AFHRL (HRTT/Dr. Ross L. Morgan)
Wright-Patterson Air Force Base
Ohio 45433

Dr. Don C. Coombs, Asst. Dir.
ERIC Clearinghouse
Stanford University
Palo Alto, California 94305

ERIC Clearinghouse
Educational Media and Technology
Stanford University
Stanford, California 94305

Commander
Operational Test and
Evaluation Force
U.S. Naval Base
Norfolk, Virginia 23511

Chief of Naval Operations, OP-07TL
Department of the Navy
Washington, D.C. 20350

Mr. George N. Graine
Naval Ship Systems Command
Code 03H
Department of the Navy
Main Navy Building
Washington, D.C. 20360

Technical Library
Bureau of Naval Personnel
(Pers-11B)
Dept. of the Navy
Washington, D.C. 20370

Director
Personnel Research Laboratory
Washington Navy Yard, Bldg. 200
Washington, D.C. 20390

Human Resources Research Office
Division #6, Aviation
Post Office Box 428
Fort Rucker, Alabama 36360

Human Resources Research Office
Division #4, Infantry
Post Office Box 2086
Fort Benning, Georgia 31905

Director of Research
U.S. Army Armor Human Research Unit
Fort Knox, Kentucky 40121
Attn: Library

Human Resources Research Office
Division #1, Systems Operations
300 North Washington Street
Alexandria, Virginia 22314

Armed Forces Staff College
Norfol, Virginia 23511
Attn: Library

Walter Reed
Div. of Neuropsychiatry
Army Institute of Research
Walter Reed Army Medical Center
Washington, D.C. 20012

Director
Air University Library
Maxwell Air Force Base
Alabama 36112
Attn: AUL-8110

AFHRL (TR/Dr. G. A. Eckstrand)
Wright-Patterson Airforce Base
Ohio 45433

Commandant
U.S. Air Force School of
Aerospace Medicine
Brooks Air Force Base, Texas 78235
Attn: Aeromedical Library (SMSDL)

Commander
Naval Air Systems Command
Navy Department Air-4132
Washington, D.C. 20360

Human Resources Research Office
Division #3, Recruit Training
Post Office Box 5787
Presidio of Monterey, California 93940
Attn: Library

Department of the Army
U.S. Army Adjutant General School
Fort Benjamin Harrison, Indiana
46216
Attn: AGCS-FA ATSAG-EA

Human Resources Research Office
Division #5, Air Defense
Post Office Box 6021
Fort Bliss, Texas 79916

Director
Human Resources Research Office
George Washington University
300 North Washington Street
Alexandria, Virginia 22314

Chief
Training and Development Division
Office of Civilian Personnel
Department of the Army
Washington, D.C. 20310

Behavioral Sciences Division
Office of Chief of Research
and Development
Department of the Army
Washington, D.C. 20310

Headquarters, Electronic System Div.
ESVPT
L.G. Hanscom Field
Bedford, Massachusetts 01730

6570th Personnel Research Lab.
Aerospace Medical Division
Lackland Air Force Base
San Antonio, Texas 78236

AFOSR (SRLB)
1400 Wilson Boulevard
Arlington, Virginia 22209

Mr. Joseph Cowan
Chief, Personnel Research Ranch (P-1)
U.S. Coast Guard Headquarters
400 7th St. S.W.
Washington, D.C. 20226

Dr. Lee J. Cronbach
School of Education
Stanford University
Stanford, California 94305

Dr. M. D. Havron
Human Sciences Research, Inc.
Westgate Industrial Park
7710 Old Springhouse Road
McLean, Virginia 22101

Dr. Joseph W. Rigney
Behavioral Technology Laboratories
University of Southern California
University Park
Los Angeles, California 90007

Dr. Benton J. Underwood
Department of Psychology
Northwestern University
Evanston, Illinois 60201

Dr. Mats Bjorkman
University of Umea
Department of Psychology
Umea 6, Sweden

Executive Secretariat
Interagency Committee on
Manpower Research, Room 251-A
1111 20th St., N.W.
Washington, D.C. 20036
Attn: Mrs. Ruth Relyea

Naval Undersea R. & D. Center
3202 E. Foothill Boulevard
Pasadena, California 91107

Lt. Col. Donald F. Ford
AF HRL (HRO)
Lowry AFB, Colorado 80230

Headquarters, U.S. Air Force
Washington, D.C. 20330
Attn: AFPTRD

Executive Officer
American Psychological Association
1200 Seventeenth Street, N.W.
Washington, D.C. 20036

Dr. Philip H. Dubois
Department of Psychology
Washington University
Lindell & Skinker Boulevards
St. Louis, Missouri 63130

Dr. Robert R. Mackie
Human Factors Research, Inc.
6780 Cortona Drive
Santa Barbara Research Park
Goleta, California 93107

Dr. Arthur I. Siegel
Applied Psychological Services
Science Center
404 East Lancaster Avenue
Wayne, Pennsylvania 19087

Dr. Alvin E. Goins, Exec. Sec.
Behavioral Sciences Res. Branch
National Institute of Mental Health
5454 Wisconsin Avenue, Room 10A02
Chevy Chase, Maryland 20203

LCDR J.C. Meredith, USN (Ret.)
Institute of Library Research
University of California, Berkeley
Berkeley, California 94720

Dr. Marshall Farr
Office of Naval Research (Code 458)
800 N. Quincy Street, Room 711
Arlington, Virginia 22217

Technical Information Exchange
Center for Computer Sciences
and Technology
National Bureau of Standards
Washington, D.C. 20234

Dr. Tom Jeffrey
Besrl, Behavioral Science
Research Laboratory
207 Commonwealth Bldg.
Arlington, Virginia 22209

Dr. Glen Finch
AFOSR, Air Force Office
of Scientific Research
1400 Wilson Blvd.
Arlington, Virginia 22209

Director, Education & Trng. Sciences
Naval Medical Research Institute
Building 142
National Naval Medical Center
Bethesda, Maryland 20014

Dr. George S. Harker, Director
Experimental Psychology Division
U.S. Army Medical Research Lab.
Fort Knox, Kentucky 40121

U.S. Army Air Defense School
Office of Director of Instruction
Attn' Mr. Wayne O. Aho
Fort Bliss, Texas 79916

Mr. Charles W. Jackson
5009 Holmes Ave., N.W.
Redstone Arsenal
Huntsville, Alabama 35805

Research Director, Code 06
Research and Evaluation Dept.
U.S. Naval Examining Center
Building 2711 - Green Bay Area
Great Lakes, Illinois 60088
Attn. C. S. Winiewicz

Dr. Ralph R. Canter
Military Manpower Research Coordinator
OASD (M&RA) MR&U
The Pentagon, Room 3D960
Washington, D.C. 20301

U.S. Army Behavior and Systems
Research Laboratory
Commonwealth Building, Room 239
1320 Wilson Boulevard
Arlington, Virginia 22209

Mr. Edmund C. Berkeley
Computers and Automation
815 Washington Street
Newtonville, Massachusetts
02160

Director, Naval Research
Attn. Library, Code 2029 (ONRL)
Washington, D.C. 20390

Director
Aerospace Crew Equipment Department
Naval Air Dev. Center, Johnsville
Warminster, Pennsylvania 18974

Commander
Submarine Development Group Two
Fleet Post Office
New York, New York 09501

Dr. Henry S. Odbert
National Science Foundation
1800 G. Street, N.W.
Washington, D.C. 20550

Education & Training Develop. Staff
Personnel Research & Develop. Lab.
Bldg. 200, Washington Navy Yard
Washington, D.C. 20390

Dr. A. L. Slafkosky
Scientific Advisor (Code AX)
Commandant of the Marine Corps
Washington, D.C. 20380

Lt. Col. F. R. Ratliff
Office of the Ass't. Secretary
of Defense (M&RU)
The Pentagon, Room 3D960
Washington, D.C. 20301

Director
Behavioral Sciences Laboratory
U.S. Army Research Institute of
Environmental Medicine
Natick, Massachusetts 01760

Dr. Bernard M. Bass
University of Rochester
Management Research Center
Rochester, New York 14627

Dr. Donald L. Bitzer
Computer-Based Education Research
University of Illinois
Urbana, Illinois 61801

Dr. C. Victor Bunderson
Computer Assisted Instruction Lab.
University of Texas
Austin, Texas 78712

Dr. Robert Dubin
Graduate School of Administration
University of California
Irvine, California 02650

Mr. Wallace Feurzeig
Bolt, Beranek and Newman, Inc.
50 Moulton Street
Cambridge, Mass. 02138

Dr. John C. Flanagan
American Institutes for Research
Post Office Box 1113
Palo Alto, California 94302

Dr. Albert S. Glickman
American Institutes for Research
8555 Sixteenth Street
Silver Spring, Maryland 20910

Dr. Carl E. Helm
Dept. of Educational Psychology
City U. of N.Y. - Graduate Center
33 West 42nd Street
New York, New York 10036

Dr. Lloyd G. Humphreys
Department of Psychology
University of Illinois
Champaign, Illinois 61820

Dr. Gabriel D. Ofiesh
Center for Ed. Technology
Catholic University
4001 Harewood Rd., N.E.
Washington, D.C. 20017

Dr. Paul Slovic
Oregon Research Institute
P. O. Box 3196
Eugene, Oregon 97403

Dr. John Annett
Department of Psychology
Hull University
Yorkshire, ENGLAND

Dr. F. J. Divesta
Pennsylvania State University
320 Reackley Building
University Park,
University Park, Pennsylvania 16802

Dr. Marvin D. Dunnette
University of Minnesota
Department of Psychology
Elliot Hall
Minneapolis, Minnesota 55455

S. Fisher, Research Associate
Computer Facility, Graduate Center
33 West 42nd Street
New York, New York 10036

Dr. Robert Glaser
Learning Research and Development
Center
University of Pittsburgh
Pittsburgh, Pennsylvania 15213

Dr. Bert Green
Department of Psychology
Johns Hopkins University
Baltimore, Maryland 21218

Dr. Albert E. Hickey
ENTELEK, Incorporated
42 Pleasant Street
Newburyport, Massachusetts 01950

Dr. Richard Myrick, President
Performance Research, Inc.
919 Eighteenth St., N.W., Suite 425
Washington, D.C. 20036

Mr. Luigi Petrullo
2431 N. Edgewood Street
Arlington, Virginia 22207

Dr. Arthur W. Staats
Department of Psychology
University of Hawaii
Honolulu, Hawaii 96822

Dr. M.C. Shelesnyak
Interdisciplinary Communications
Smithsonian Institution
1025 15th St., N.W./Suite 700
Washington, D.C. 20005

Educational Testing Service
Division of Psychological Studies
Rosedale Road
Princeton, New Jersey 08540

Dr. George E. Rowland
Rowland and Company, Inc.
P. O. Box 61
Haddonfield, New Jersey 08033

Department of the Navy
Office of Naval Research
Arlington, Virgin's 22217
Code 458

Dr. Harold Gulliksen
Department of Psychology
Princeton University
Princeton, New Jersey 08540

Dr. Marty Rockway
AFHRL (TT)
Human Resources Lab.
Lowry Air Force Base, Colorado